NISTTech

Laser Guided Tip Approach with 3D Registration to a Surface

Atomic scale, precise, three dimensional, real-time localization of a probe tip and a sample surface

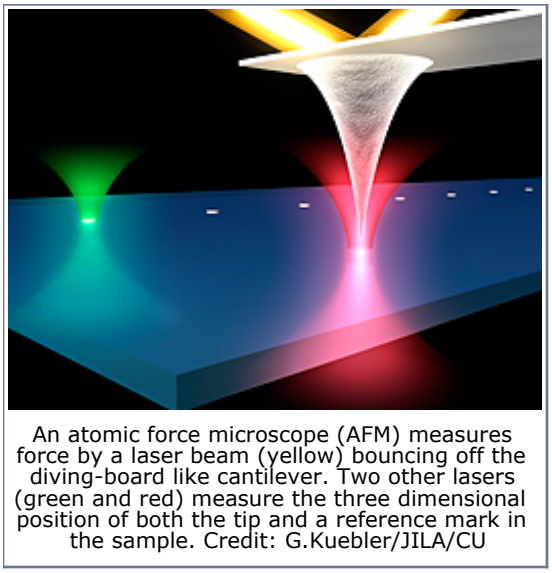
Description

In atomic force microscopy (AMF), it is not possible to reliably exchange tips and return to the same nanoscale feature. This is exacerbated by samples that lack surface height variation. This invention demonstrates that individual nanoscale objects can be successfully imaged by the same tip after retraction and re-approach, as well as after an exchange of tips. Finally, different types of tips can be exchanged and the same feature imaged and reimaged.

This automated, high-speed technique is suitable for atomic scale manufacturing or research. Sharp objects such as tips can be moved to a specified location on a surface with high precision and accuracy in three dimensions. Beams from one or more lasers detect tips and sample positions using light scattering from fiducial marks on each surface. Samples and/or tips, mounted on moveable stages, are programmed for rapid, precise movement. Optical signals from both beams guide the tip-surface approach at the sub-nanometer level.

Also see NIST Docket # 05-019, below under references.

Images



An atomic force microscope (AFM) measures force by a laser beam (yellow) bouncing off the diving-board like cantilever. Two other lasers (green and red) measure the three dimensional position of both the tip and a reference mark in the sample. Credit: G.Kuebler/JILA/CU

Applications

- **Tip-based research instrumentation**
  Compatible with scanning probe microscopy and atomic force microscopy
- **Lithography and other manufacturing techniques**
  Implement with proximal probe lithography, dip-pen lithography, tip-indent lithography, molecule array manufacturing, and single atom manipulation

Advantages

- **Applicable for any atomic scale tip-based research or manufacturing technique**
- **Rapid precision manufacturing**
  Rapid tip replacement and surface registered re-engagement during a manufacturing process or an experiment
- **Tip substitution**
  Multiple tips could be toggled into and out of engagement at a well defined surface location to enable complex manufacturing processes

Abstract

Here we introduce a technique which allows sharp objects (e.g. scanning tunneling microscope tips, atomic force microscope tips, near-field scanning optical microscope tips, pipette tips, etc.) to be rapidly brought into close proximity to a particular region of a surface with high precision and accuracy in three dimensions. The method has potential applications in a broad array of tip-based research instrumentation and manufacturing techniques, including: scanning probe microscopy, atomic force microscopy, proximal probe lithography, dip-pen lithography, tip-indent lithography, molecule array manufacturing, and single

atom manipulation.

In a typical atomic force microscope, course approach between tip and sample is achieved via a translation by a long range (0.1-1000 microns) stage followed by a fine stage movement (0.1-1000 nm); if the surface is not found, this process is repeated. Often, optical microscopes are used to aid in this process. Prior art does not allow registered tip approach due to the lack of a reliable method to yield precise three dimensional simultaneous localization of a tip and a sample surface. This knowledge is necessary in order to bring these objects into close proximity or contact with high resolution registration and speed.

Inventors

- Carter, Ashley R.
- King, Gavin M.
- Perkins, Thomas T.

Citations

1. NIST Docket # 05-019, U.S. Patent Application # 11/545,498

G.M. King, A.R. Carter, A.B. Churnside, L.S. Eberle and T.T. Perkins. Ultrastable atomic force microscopy: Atomic-scale stability and registration in ambient conditions. *Nano Letters*, Article ASAP, March 12, 2009. (DOI: 10.1021/nl803298q).

A.R. Carter, G.M. King and T.T. Perkins. Back-scattered detection provides atomic-scale localization precision, stability, and registration in 3D. *Optics Express* V. 15, No. 20. Oct. 1, 2007.

Related Items

- TechBeat: Picoscale Stability in Room-Temp. AFM

References

- U.S. Patent Application #20110035848 filing date 08-05-2010, Expires on 3/30/2031
- Docket: 08-020

Status of Availability

This invention is available for licensing exclusively or non-exclusively in any field of use.

Last Modified: 05/29/2015